Aramco

DEEP SPACE | DEEP OCEAN

Aramco Technology and
Operational Excellence Forum

Session 2: Electric Power in Sea & Space

Deep Dive 3: Advanced Technologies & Materials Track

Tuesday, April 7, 2015, 3:45pm-5:15pm

The Woodlands, TX

Power Panel

- Richard Voight *Subsea Power Mgmt. & Distribution*
  - Senior Executive Engineer, Subsea Systems, INTECSEA
- Frank Davies *Space Power Mgmt. & Distribution*
  - Senior Project Engineer, NASA Johnson Space Center
- Daniel Winslow *Downhole/Subsea Power Gen. & Storage*
  - Senior Technical Advisor, Halliburton
- Koorosh Araghi *Space Power Generation & Storage*
  - Technology Manager, NASA Johnson Space Center
- Jeff George *Moderator*
  - Advanced Power Project Manager, NASA Johnson Space Center

Panel Purpose & Goals

Purpose: For Electrical Power…

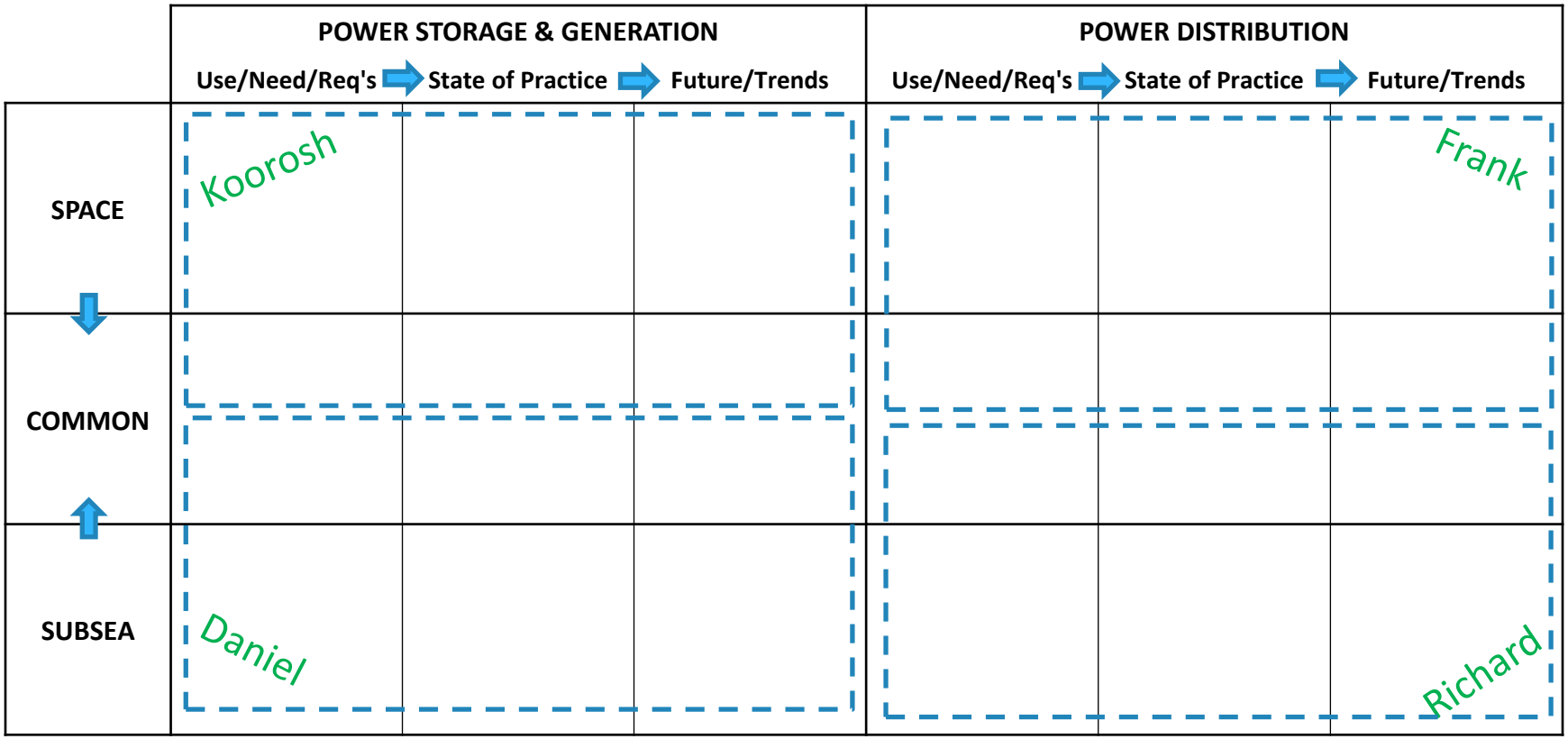
- "*Deep Space, Deep Ocean: Exploring Crossover Technologies in the Space and Energy Sectors."*
- "Both the oil and gas and aerospace industries operate in harsh, often unexplored environments requiring unique solutions for safety and reliability."
- "…go on a "deep dive" to analyze common challenges and set the stage to solve these challenges through technology collaboration."

Goals:

1. Survey Electrical Power Gen/Stor/Mgmt/Distr for Subsea & Space
2. Identify Commonalities (crosswalk chart)
3. Panel Engagement, Dialogue
4. Audience Engagement, Questions, Dialogue & Input

Finding Common Ground

ELECTRIC POWER IN SEA AND SPACE



Agenda

• Intro & Problem Statement	Jeff	5 min
• Subsea Power Mgmt & Distr	Richard	15 min
• Space Power Mgmt & Distr	Frank	15 min
• Subsea Power Gen & Stor	Daniel	15 min
• Space Power Gen & Stor	Koorosh	15 min
• Crosswalk Chart	Jeff	5 min
• Audience Q&A, Discussion		20 min
		90 min

Comparing Electric Power in Sea and Space

	POWER GENERATION & STORAGE			POWER MANAGEMENT & DISTRIBUTION		
	Use/Need/Req's ⇨	State of Practice ⇨	Future/Trends	Use/Need/Req's ⇨	State of Practice ⇨	Future/Trends
SPACE	ISS, Orion. Hot &/or Cold (-150 to +150°C). Reduced Gravity. Radiation. Dusty Moon/Mars. Low Mass!	1's-10's-250 kWe. Recharg. Batteries. Fuel Cells. Solar Photovoltaics. Radioisotope Generators.	PEM & Solid Oxide Fuel Cells. Li-Ion advancement. Better solar cells & array deployment. Nuclear power & propulsion.	ISS, Orion. Hot &/or Cold (-150 to +150°C). Reduced Gravity. Radiation. Dusty Moon/Mars. Low Mass!	Silicon semicond. 28, 120, 160 Vdc. 10's m transmission. Copper wire. Redundancy.	Higher powers: 100'skWe-MWe's. New SiC, GaN semi. Aluminum wires. 300+ Vdc.
COMMON	Harsh Environ's. Remote Ops. Safety & Reliability.	Hi operating temps. Lith. prim. batteries. Li-Ion rechg. batt's.	High energy density recharg. batteries. Fuel cells.	Safety & Reliability. Harsh Environ's. Remote Ops, Deploy, Reconfig. Volum. efficiency.	Copper wire. Redundancy. DC-DC converters, inverters, variable speed drive elec's.	DC Power. Increased Safety & Reliability. Partnering / Knowledge Sharing.
SUBSEA, DOWNHOLE	Subsea: Power Grid Downhole: Directional Drilling, Logging/NucMagRes, Wet, Mud, HiPress, HiTemp.	Topside Diesel or Gas Turbines. BHA: 10'sW-1kWe. Primary Batteries. Mud turboalt. 200°C Formations	230°C Formations. 150°C Rechg. Batt's. 10's kWe BHAs. Laser or Elec.Disch. Drilling.	Subsea: Production vs. Enhancement, Pumps, Compressors, Flowline heating, Downhole: Wireline	Vast grid (vert&hor) w/ Hi topside funct. Multi-km umbilicals. 10,000 fsw, 4500psi. 15kpsi shutin press. 50-60Hz HiVolAC. Wet-or-Dry mate connectors to 36 kV.	More seafloor funct. LowFreq HVAC (16 2/3 Hz). MedVolDC (120+ kVdc). Subsea Factory. SWIT (subsea water inj & treatment).